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SEASONAL CHANGES IN CARBOHYDRATE COMPOSITION OF CACAO PODS OF *THEOBROMA CACAO* L.

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ABSTRACT

Investigations on seasonal changes of carbohydrate contents of cacao pods (*Theobroma cacao* L.) were carried out at Central Plantation Crops Research Institute (Regional Station), Vittal during the year 1970-71. Seasonal fluctuations in reducing sugars, non-reducing sugars, total sugars and starch of husk and beans are described.

All the soluble sugars are found to be rich in husk than in beans whereas the content of alcohol insoluble solids (starch) was obtained more in beans than in husk. However, the carbohydrate constituents of cacao pods are very much variable in relation to different months.

INTRODUCTION

The carbohydrate content in the cacao fruits is of vital importance from the nutritive point of view. The fluctuation in carbohydrates are influenced by the seasonal environmental factors and by the growth activity of the plants as reported in various deciduous, subtropical and tropical fruit trees (Cameron and Brost, 1938; Sharples and Burkhart, 1954). Humphries (1944) has also reported carbohydrate contents in developing pods but without any consideration of seasons. But, carbohydrate levels at different times during the years have not previously been determined in cacao pods. So in order to have better understanding of carbohydrate metabolism in cacao, seasonal changes in concentration of sugars and starch in fruits need to be studied. Therefore, the present investigation was conducted to determine the seasonal fluctuations in carbohydrate contents of cacao pods.

MATERIALS AND METHODS

Five trees of cacao, uniform in growth and productivity and growing under identical soil and cultural practices in the mixed garden of arecanut of the Central Plantation Crops Research Institute, Vittal were selected for these investigations. Three pods of different group and size were collected per tree and formed one replication for chemical analysis. Samples were collected at bimonthly intervals, i.e., May, July, September, November, January and March of the 1st day of the first week during the year 1970-71. Immediately after collection, samples were brought to the laboratory and beans and husk were separated; chopped off and kept in oven at $85^{\circ}\text{C} \pm 1^{\circ}\text{C}$ for drying. Subsequently samples were powdered and analysed the carbohydrate constituents in dry material.

Chemical analysis

Reducing and total sugars were estimated from alcoholic extract according to the method described by Lane and Eynon (1923) and modified by Heinze and Murneek (1940). The amount of non-reducing sugar was known by subtracting

the reducing sugars from total sugars and multiplying the same by factor 0.95. The starch was estimated from the dried residue of alcohol insoluble solids (AIS) in terms of glucose after acid hydrolysis with takadiastase enzyme (Heinze and Murneek, 1940). The figures thus obtained were multiplied by 0.90 to get the amount of starch present (A. O. A. C., 1960).

Experimental findings

Data pertaining to seasonal variation in carbohydrates are presented in Table 1.

The reducing sugars content were quite high in the pods of September, but considerably decreased in the month of March (Table 1). The variations in the pod components due to the effect of different seasons were found to be highly significant. In general, the percentage of reducing sugar varied within the beans and husk as well in varying months.

The non-reducing sugar content was, however, the same as in the case of reducing sugars excepting in case of January and March where beans showed more value than the husk. Considerably higher non-reducing sugar concentration could be observed during the winter months for husk as well as in beans (Table 1). Similarly the husk of cacao pods, on all the sampling dates contained considerably more sugars than in beans. However, increase in sugar content in cacao pods are comparatively very less than the starch. It indicates that the maximum amount of starch is accumulated in cacao pods and statistically differences are highly significant. On the other hand, bean has accumulated more total sugars in the month of September followed by November and May respectively whereas husk contained more in the month of May followed by November. In general the total sugar content was more in husk than in the beans (Table 1).

TABLE I
Seasonal changes in carbohydrate composition of cacao pods

Months	Percentage of Carbohydrates							
	Redu. sugars		Non-redu. sugars		Total sugars		Starch	
	Husk	Beans	Husk	Beans	Husk	Beans	Husk	Beans
May	1.030	1.195	3.380	0.386	4.589	1.597	31.089	32.373
July	1.164	0.594	1.949	0.691	3.236	1.342	19.965	16.279
Sept.	1.265	1.328	0.497	0.882	1.789	2.210	22.422	23.163
Nov.	0.985	1.022	1.656	0.579	2.728	1.632	17.230	16.769
Jan.	1.056	0.523	0.957	0.975	2.064	1.550	17.759	27.683
March	0.663	0.518	0.138	0.205	0.809	0.726	21.420	28.542
Mean	1.028	0.864	1.430	0.620	2.536	1.510	21.648	24.135
C. D. at 1%	0.083	0.125	0.167	0.167	0.150	0.119	1.485	1.544

On the other hand, the percentage of starch content in cacao husk was found to be high in the month of May but the extent of increase with season of the better growth and development of pods was found to be variable for its

content (Table 1). During the month of July, a sharp decrease was found in its amount followed by increase in the month of September. And this dwindling trend was recorded for the month of November, January and March respectively. However, the higher starch content could be seen in the summer season (May). The overall trend in starch content of beans and husk was higher in all the months and statistically the data are highly significant. In general, beans of cacao fruits showed maximum amount of starch than the husk of the pods.

DISCUSSION

Present studies indicated slight increasing trend in the concentration of starch in March and heavy accumulation in the month of May. This heavy accumulation of starch in summer season was possibly due to reduction in concentration of reducing, non-reducing, and total sugars in pods and complete mobilization of starch from the different flushes and their conversion into starch because of rise in temperature during the period. Jones and Steinacker (1951) found that with the warming of the weather in early spring, before appearance of the new growth, conversion of sugars to starch led to the accumulation of starch. Hence, rise in starch in the present study is quite understandable. Further it can be supported by the findings of Winkler and Williams (1945) of *Vitis vinifera*; Randhawa and Soni (1969) in the flushes of lemon and Rodrigues and Ryan (1960) in avocado shoots.

Kursanov and Pavlinova (1950) considered that the nearest precursors of sucrose in plants are not phosphorylated sugars nor fructose but compounds with 1, 4 α -glucoside linkage such as maltose, dextrine and starch. This would perhaps explain the presence of maltose and as a major constituents of starch in cacao pods. During the month of May the sugar content has slightly increased in the case of husk, it may be due to increase in concentration of raffinose. This might be expected since raffinose is synthesized from sucrose (Rast *et al*, 1963).

Evidence at hand does not permit any definite conclusion as to the nature of the correct reaction, but the possibility exists of one or more enzyme system being involved, under these conditions, conversion of starch to sugar probably constitutes an upset in the normal mechanism of starch-sugar equilibrium.

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